

altogether the flesh-spicule. In them the horny element is rather more developed than in Dr. Allen's sponge, and it yet remains to be considered how far they are related to *H. birotulata*; they will therefore be more particularly referred to when the rest of the collection comes to be described.

EXPLANATION OF PLATE XIV.

- Fig. 1.* *Higginsia coralloides*, half actual size, after a photograph by Mr. John Chard, Liverpool Museum.
- Fig. 2.* Smooth bent acerate skeleton-spicule of same, scale 0·001 to 0·0625 inch.
- Fig. 3.* Smooth straight acerate subskeleton-spicule of same, scale 0·001 to 0·0625 inch.
- Fig. 4.* Spined bent acerate surface-spicule of same, scale 0·001 to 0·0625 inch.
- Fig. 5.* Same spicule, scale 0·001 to 0·125 inch.
- Fig. 6.* Smooth conically spined stellate spicule of *Donatia parasitica*, scale 0·0002 to 0·083 inch.
- Fig. 7.* Spino-capitately rayed spicule of same, scale 0·0002 to 0·083 inch.
- Fig. 8.* Subterminally inflated spinulate spicule of same, scale 0·0004 to 0·0416 inch.
- Fig. 9.* Entirely spined quadriradiate spicule of *Hymeraphia* unnamed, scale 0·0002 to 0·0416 inch.
- Fig. 10.* Bent acute spicule of same sponge, scale 0·0004 to 0·0416 inch.
- Fig. 11.* *Halichondria birotulata*, short branch, actual size, from a drawing by my daughter, Eva Higgin.
- Fig. 12.* Subcylindrical skeleton-spicule of same, scale 0·0004 to 0·0625 inch.
- Fig. 13.* Acuate subskeleton-spicule of same, scale 0·0004 to 0·0625 inch.
- Fig. 14.* 12-rayed birotulate flesh-spicule of same, five rays only at each end shown, to avoid confusion of lines; scale 0·0005 to 1 inch.
- Fig. 15.* End view of one of the umbrella-shaped extremities of same spicule, scale one 1900th to 1 inch.

XXV.—*On the Structure of the Lower Jaw in Rhizodopsis and Rhizodus* *. By R. H. TRAQUAIR, M.D., F.G.S., F.R.S.E., Keeper of the Natural-History Collections in the Museum of Science and Art, Edinburgh.

AMONG the detached and broken-up remains of the Coal-measure fish known as *Rhizodopsis sauroides*, one of the most frequently observed is a bone of a somewhat narrow and elongated form, truncated and somewhat expanded at one extremity, which may be assumed to be the anterior, and pointed at the other or posterior. One margin, nearly straight,

* Read before the Royal Physical Society of Edinburgh, Feb. 21, 1877.

save just in front, where it shows a slight convexity, is set with a single row of small pointed teeth of nearly uniform size; but the anterior extremity bears in addition a single more or less incurved laniary tooth, much larger than the others, and also more internal in its position; the opposite margin, thin and sharp, displays a gently flexuous contour. Seen from the inner aspect, the anterior extremity of the bone presents a conspicuous thickening, in which the large laniary is socketed, and which at the dental margin passes into a delicate ledge, which runs back for some distance along the roots of the smaller teeth.

This bone, whose external form has been well described by Messrs. Hancock and Atthey*, was considered by them to be the *præmaxilla* of *Rhizodopsis*, being obviously distinct from another well-known dentigerous bone, which is indisputably the maxilla, and closely resembles in form the maxilla of *Megalichthys*. To all appearance it would also seem to be distinct from the mandible, the margins of which "are nearly parallel," and which displays, besides a large laniary tooth in front, "three or four others placed along the ramus, in a line within the small teeth."

With the bones described by Messrs. Hancock and Atthey as the *præmaxilla*, maxilla, and mandible of *Rhizodopsis*, every student of carboniferous ichthyology must be familiar. The interpretation of the first of these as "*præmaxilla*" has been accepted by the Messrs. Barkas†, and, so far as I am aware, has remained hitherto unquestioned. Nevertheless the accuracy of its determination as such was to me a matter of doubt from the first. It is true the bone in question does in some measure remind us of the elongated *præmaxilla* of Teleostei of the most specialized type, in which that element, loosely articulated with the front of the skull, extends backwards so as to shut out the now edentulous maxilla from the edge of the mouth (*Perca*, *Gadus*, &c.). But as *Rhizodopsis* is a Crossopterygian ganoid of the type possessing two dorsal fins and subacutely lobate pectorals, one would naturally expect that its *præmaxillary* bones would resemble in form and relations those of its natural allies, whether rhombiferous or cycliferous, in all of which, whose cranial osteology is sufficiently known, each *præmaxilla* is comparatively small and short, firmly fixed to the front of the cranial shield, and, in fact, very unlike the bone of *Rhizodopsis* which has been

* Ann. & Mag. Nat. Hist. 1868, ser. 4, vol. i. pp. 350, 351.

† 'Manual of Coal-measure Palæontology,' by T. P. Barkas (London, 1873), p. 24, pl. ii. fig. 61; W. J. Barkas in 'Monthly Review of Dental Surgery.'

so interpreted. How to fit this bone into the præmaxillary region was to me somewhat puzzling; and, accordingly, to find it *in situ* in the head of the fish was an object to be attained, before giving-in adherence to the views usually maintained regarding it.

A short time ago my friend Mr. Ward of Longton, to whose liberality in lending specimens from his magnificent collection I am on this, as on other occasions, so largely indebted, sent me a number of unusually good examples of the head of *Rhizodopsis* preserved in nodules of hard ironstone from the Coal-measures of Fenton in Staffordshire. One of these displays the entire extent of the gape on both sides of the head. Each maxilla measures here $1\frac{1}{16}$ inch in length; the upper margin is injured; but the lower, bearing one row of small teeth, is quite intact; the anterior extremity shows the little articular process projecting upwards and forwards as in the similarly shaped maxilla of *Megalichthys*. Now, placed between and articulating with the anterior extremities of the right and left maxillæ, while they are joined with each other in the middle line, are two small dentigerous bones forming the front edge of the mouth below the snout. Each of these two bones is nearly as high as long, these measurements being respectively $\frac{4}{16}$ and $\frac{5}{16}$ inch; they are firmly fixed to each other and apparently also to the front of the cranial shield: the teeth, which in this specimen are seen attached to them, resemble those of the maxilla; but in another example there are traces of others somewhat larger. That we have here the true *præmaxillæ* is beyond all doubt; some other signification must therefore be found for the bones hitherto considered such. Turning now to the mandible, both rami of which are displayed in the specimen under description, we find that over a considerable area the bony matter of the outer aspect has flaked off, leaving behind it a pretty sharp cast with sutural lines. On close examination a suture is now seen commencing near the posterior extremity of the upper margin of the jaw, and, passing gradually downwards and forwards, marks off as *dentary* an element precisely the counterpart in shape of the reputed præmaxilla. The pointed extremity is placed backwards, the enlarged one forwards, the toothed margin upwards. The rest of the outer surface of the mandible is composed of at least three additional bony plates, separated from each other by sutures which pass obliquely forwards and upwards. The posterior and largest of these, covering over the articular region of the jaw, may be perhaps equivalent to the *angular* element, though it also occupies very much the place of a *supraangular*; the other two, in

front of the latter and below the dentary, may be called *infradentary*; and there is also some evidence of a fourth, small plate on the lower margin of the jaw, separating here the angular from the first infradentary for a little distance*.

In another specimen, compressed vertically and showing the top of the head, both maxillæ are seen, forming the upper margin of the mouth, while, forming its lower margin, both dentaries are seen on the edge of the nodule, here retaining their bony substance and external sculpture. Their contour proves beyond a doubt that the dentary element of the mandible of *Rhizodopsis* is undistinguishable from the bone hitherto reckoned as præmaxilla, but which I have already shown cannot possibly be so. The very same thing is most clearly shown in a shale specimen belonging to Mr. Plant of Salford, in which a vertically compressed head is seen from below; so that I have no hesitation in affirming the identity of the bones in question.

Here, however, an objection to this view may be raised. The mandible of *Rhizodopsis* when perfect, as in most of the specimens from Fenton now before me, shows not merely one large tooth in front, but two or three additional ones behind it and internal to the series of small teeth, though, as stated by Messrs. Hancock and Atthey, these additional larger teeth "are seldom present." What has become of these in the detached dentary, if such be the real nature of the reputed præmaxilla?

A ready explanation of this is found in the structure of the lower jaw of certain Old Red Sandstone "Dendrodonts," in which the laniary teeth are not attached to the dentary bone proper, but to a series of accessory "internal dentary" pieces articulated to its inner side†. Should this be also the case with the posterior laniaries of the mandible of *Rhizodopsis*, then, in cases where its elements are broken up and separated, these additional pieces will also get detached, and the absence of all but the anterior laniary in the isolated dentary bone will thus be amply accounted for.

The material at hand not furnishing me with absolute proofs of this condition in *Rhizodopsis*, I now turned to its

* That these sutures on the outer surface of the mandible in *Rhizodopsis* have not been previously observed is fully accounted for by the difficulty of tracing the line of demarcation between constituent and closely united osseous elements, in cases where we have to deal with a granulated or otherwise ornamented external bony surface. Such lines of demarcation are more easily determined where the bones are seen from the inner surface, or where a sharp cast in hard ironstone of that inner surface has been preserved.

† See Pander's 'Saurodipterenen, Dendrodonten, &c. des devonischen Systems,' pp. 41-43, tab. x. figs. 2, 3, 4, 14, 22.

gigantic ally, the *Rhizodus* of the Scottish Lower Carboniferous strata. I had previously observed the not uncommon occurrence of detached dentigerous bones belonging to *R. Hibberti*, which had exactly the same shape as the so-called præmaxillæ of *Rhizodopsis*, and, like them, frequently bear only one laniary, the large one in front. On now carefully examining the exterior of several more or less perfect mandibles, it became at once evident that the bone in question was nothing more or less than the dentary element, the rest of the outer surface of the jaw being formed by several additional bony plates quite analogous to those occurring also in *Rhizodopsis*. In *Rhizodus* there are four such additional plates: of these the posterior one, covering up the articular region, is probably equivalent to the angular element, though, indeed, occupying also the position of a supraangular; while in front of it, below the dentary, and forming the lower margin of the jaw, are three others, diminishing in size from behind forwards, and separated from each other by sutures passing obliquely forwards and upwards, and to which, as in *Rhizodopsis*, the name of *infradentary* may be applied.

Several detached specimens of the dentary bone of *Rhizodus* in the Edinburgh Museum exhibit its inner surface, which is also conformed just as in the corresponding element, the so-called præmaxilla, of *Rhizodopsis*. The upper margin, comparatively thin, is set with one row of small teeth; but at the symphysial extremity the bone shows a great thickening, the anterior part of which is marked by a very rough area for articulation with the bone of the opposite side. In this thickening is implanted the anterior great laniary, behind and close to which is another socket, usually empty, sometimes occupied by a "twin" tooth*. There are also in the Museum several jaws seen from the internal aspect and in which the posterior laniaries are present; but being imbedded in hard ironstone, the surface of the bone is so injured as to render recognition of sutures a matter of difficulty: they show, however, very clearly that these posterior laniaries are implanted in a thickened ledge, somewhat nodulously enlarged round the base of each, and continuing backwards the symphysial thickening of the dentary proper—this ledge with its teeth being totally absent in the detached dentaries above alluded to. I now selected for special preparation two jaws, seen from the outer surface, and fortunately imbedded in a rather soft laminated clay. The first of

* The more posteriorly situated laniaries of *Rhizodus* occur also occasionally double.

these was a portion of a comparatively small jaw, $3\frac{1}{4}$ inches in length, and broken across $\frac{3}{4}$ inch behind the stump of the second laniary; and by softening the matrix with water, I succeeded in completely detaching it and cleaning its inner surface. The surface of the bone being here quite intact, I obtained a clear proof of the fact which I had anticipated, viz. that the second laniary tooth is attached to a separate piece of bone articulated by a distinct suture to the anterior thickening of the dentary, and having its outer surface in apposition with the flat inner surface of the dentary behind that thickening. The next jaw was a larger one, measuring 14 inches in length, showing three entire laniaries and the stump of a fourth, the articular extremity being, however, unfortunately broken off. Having covered up the outer surface of the specimen with a sufficient mass of Portland cement, I turned it over and worked down upon it from the other side, the preparation thus obtained entirely corroborating the conclusions previously arrived at. The large teeth are seen to be borne upon a thickened ledge, diminishing in strength from before backwards, the anterior part of which is the previously described symphyseal thickening of the dentary proper, and carries the first great laniary; the suture between that and the anterior of the accessory internal dentary pieces bearing the second laniary is distinctly seen; but posteriorly the separation of the others is obscured by the obstinate adherence to the bone of a thin layer of the matrix, which cannot be thoroughly cleared off without injuring the surface. My attention was next directed to a block of the same laminated clay containing several bones of *Rhizodus*. From this I succeeded first in extracting the anterior half of an isolated dentary bone, that of the right side, showing the stump of the symphyseal laniary with the adjoining empty socket. Then, lying about 2 inches from it in the same block, I observed a piece of bone bearing a large tooth, which, on being in like manner extracted entire, proved to be nothing more or less than the *detached* accessory piece carrying the second laniary of the same jaw, and would have fitted perfectly on to the dentary found beside it, had not the latter been a little distorted by crushing. Finally, several vertical sections through another mandible led to the very same result—namely, that the laniary teeth behind the great anterior one are attached to bone which is quite distinct from that of the dentary proper; and as the piece to which the second laniary is attached has occurred quite isolated, we may very safely assume that the third and fourth had also each a piece for themselves.

Summary.

The general results of the researches briefly detailed above may be summed up as follows.

The mandible has, as far as ascertained, essentially the same structure in *Rhizodopsis* as in *Rhizodus*. In both, the *dentary* element is narrow and pointed posteriorly, its upper margin bears one row of small teeth, while at the symphysis it is peculiarly thickened where it bears the first or anterior laniary. This bone, turned upside down, has, in *Rhizodopsis*, been previously considered to be the præmaxillary; the last-named element of the skull of that fish has now, however, been ascertained to be a different bone, which is quite similar in form and relations to the præmaxilla in other Crossopterygii.

The laniary teeth behind the anterior one are borne upon separate *internal dentary* ossicles, which, when the constituent elements of the lower jaw are broken up and separated, will also become disarticulated and dispersed. This is absolutely proved in *Rhizodus*, and may be considered morally certain in *Rhizodopsis*, though a clear view of the inner aspect of the complete mandible of the latter, with the posterior laniary teeth *in situ*, has not yet been obtained.

Below the dentary the inferior margin of the jaw is formed by a series of *infradentary* plates, while posteriorly the articular region is covered by a plate corresponding in position apparently both with the *angular* and *supraangular* elements. I may add that, in one specimen of *Rhizodopsis*, I have seen very distinct evidence of a *splénial*.

The great complexity of the structure of the mandible in these forms and in the allied "Dendrodonts" of the Old Red Sandstone need not astonish us when we take into account the remarkably segmented splénial of the recent *Amia*, or the similarly segmented maxilla of *Lepidosteus*.

XXVI.—*Description of a new Form of Ophiuridæ from New Zealand.* By EDGAR A. SMITH, F.Z.S., Zoological Department, British Museum.

[Plate XV.]

THERE are three specimens of this very remarkable form of Ophiuridæ in the British Museum—one presented by Major